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Genetic association between milk production and weight performance of Pitangueiras cattle (5/8 Red Poll:3/8 Zebu)*

Vera Lucia Cardoso[1], *Raysildo Barbosa Lôbo*[2] *and Henrique Nunes de Oliveira*[3]

ABSTRACT

Data on 1,567 first lactations and 1,776 records of steers, including body weight at time of allocation to feedlot and live-weight-for-age, of Pitangueiras cattle were used to estimate predicted differences of sires. Data were also used to compute the genetic correlation between milk and weight traits, and to calculate expected correlated responses for weight performance traits. Animals were raised in São Paulo State and males were allocated to the feedlot at an average age of 28 months. Overall means and coefficients of variation (CV) were respectively 1,930 kg (CV = 56%), for 305-day milk yield (MY305); 234 days (CV = 50%), for lactation length (LL); 28 months (CV = 17%) and 365 kg (CV = 16%), for age and body weight at allocation to the feedlots (AGEI and WAF); and 0.421 kg (CV = 13%), for live-weight-for-age (LWA). Predicted differences for MY305, WAF and LWA ranged from -521 to 612 kg; -14 kg to 22 kg; and -0.014 kg to 0.021 kg, respectively. The genetic correlation between MY305 and WAF was -0.24 ± 0.15 and -0.35 ± 0.14 for MY305 and LWA. The correlated responses for WAF and LWA resulting from direct selection for milk production were 1.667 kg and 0.0016 kg, respectively. Selection for milk production did not cause detrimental effects on weight of animals raised for beef.

INTRODUCTION

Semi-extensive dual purpose systems based on the utilization of crossbred cattle are quite common in tropical countries because they constitute an economic alternative, taking into account the following aspects pointed out in the review of Holmann *et al.* (1990): a) Feed resources are of low quality; b) concentrate feeds are scarce, expensive and of variable quality; c) appropriate technical information is not always available; d) dual purpose systems are flexible with lower risk compared to intensive dairy systems.

Although this kind of system can be easily found in Brazil, there are no reports on the genetic association between milk production and beef traits, which could provide information about the potential of crossbred populations to produce both milk and meat.

In most Western European countries and Israel, the meat consumed is produced from dairy and dual purpose cattle, because of the small territorial areas of these countries which do not permit extensive beef production, the decrease in size of rural properties and the economic policies of the EEC. For these European countries, as well as for Israel, correlated responses of beef traits to selection for milk have been important for

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[1] Instituto de Zootecnia, Estação Experimental de Zootecnia, Caixa Postal 206, 14030-100 Ribeirão Preto, SP, Brasil. Send correspondence to V.L.C.

[2] Departamento de Genética, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, SP, Brasil.

[3] Faculdade de Medicina Veterinária e Zootecnia, Universidade Estadual Paulista, Botucatu, SP, Brasil.

designing breeding programs for dual purpose populations (Soller *et al.*, 1966; Zarnecki and Stolzman, 1986).

In general, estimates of genetic correlation between dairy and beef traits have been obtained from the correlation between progeny tests of bulls for milk and beef characters, adjusted for number of progeny and heritabilities of the characters.

Mason (1964) estimated the genetic correlation between milk production and some beef traits (live and carcass traits), from records of private Dairy Shorthorn and Red Poll herds located in England and Wales. All estimates were small and not significantly different from zero. Similar results were obtained by Soller *et al.* (1966), in a study based on 12-month live-weights of Israel-Friesian bull calves collected during routine progeny testing of dairy sires for live-weight-for-age of their bull calves and milk production of their daughters, and by Zarnecki *et al.* (1985) (cited by Zarnecki and Stolzman, 1986).

Mason *et al.* (1972) found a range of estimates of genetic correlations between milk production and growth and carcass traits of British Friesian cattle, from -0.68 for carcass weight-for-age, to 0.61 for % bone in rib, with most estimates negative, but close to zero.

Calo *et al.* (1973b), in the United States, found that the average genetic correlations of milk production with beef traits ranged from 0.02 to 0.28 for body weights at several ages. The estimates decreased as the age of animals increased, with some negative estimates for older ages. The authors estimated expected correlated response by ranking the bulls according to their estimated breeding values for beef traits and selecting the top 10%. For example, at 15 months of age, the superiority of the top 10% for body weight was 40.6 kg, so that, on average, progeny of these selected bulls would be expected to exceed contemporaries by 20.3 kg.

MATERIAL AND METHODS

The data

Data was recorded on productive performance of Pitangueiras cattle (5/8 Red Poll:3/8 Zebu) from Três Barras Farm, which is located in the northern region of the state of São Paulo.

This studied Pitangueiras herd have been selected for milk production for the last 40 years and since 1980 progeny testing for milk production has been done routinely. More information about the origin and distribution of Pitangueiras cattle may be found in Lôbo and Reis (1989), and about climate for the region, in Lemos *et al.* (1990).

About 1,700 first normal lactation records (305-day milk yield), made between 1984 and 1990 from daughters of 70 sires, and the weights when allocated to feedlots (at an average age of 28 months) and live-weight-for-age measures from about 1,850 males sired by 51 bulls, obtained between 1986 and 1990, were used in the present study. The animals were grouped according to paternal half-sib groups. Information on both male and female progenies of 42 sires were available. The live-weight-for-age was obtained by dividing the weight at allocation to feedlot by the age of animal in days (see Mason, 1964; Soller *et al.*, 1966).

Management

The lactating cows were kept on good quality pastures of *Panicum maximum*, and received concentrates according to their production, as well as corn silage supplementation during the dry season. They were milked twice a day with a milking machine. Lactations were considered terminated when the monthly milk recording showed production below 3 kg of milk day. About 60 days before calving the heifers were taken to the milking parlour daily in order to get used to the milking routine.

Calves were weaned at 50 days and after weaning, received *Cynodon dactylon* hay *ad libitum*. At about 210 days, the male calves were castrated and kept on good quality pastures of *P. maximum* until the approximate age of 24 months. In June of each year, steers with weights of 270 kg or more were allocated to feedlots.

Statistical analysis

Data were analyzed statistically using LSMLMW-87 (Least Squares and Maximum Likelihood Computer Program) described by Harvey (1987). To estimate heritabilities for 305-day milk yield (MY305), weight at allocation to feedlots (WAF) and live-weight-for-age (LWA), the following general mixed model was utilized:

$$Y_{ijkl} = \mu + A_i + b_{ij} + F_k + e_{ijkl}$$

where:

Y_{ijkl} = value observed for each dependent variable;
μ = overall mean;
A_i = genetic group of sire (fixed effect);
b_{ij} = sire: genetic group of sire (random effect);

F_k = other fixed effects (year-season of calving for MY305; year and age at weighing for WAF; year and season of birth and year of weighing for LWA);
e_{ijkl} = random error.

This model corresponds to MTY = 03 as described by Harvey (1987).

The following sire genetic groups were defined for all analyses: **genetic group 1**: first generation sires, 5/8 Red Poll:3/8 Zebu; **genetic group 2**: second generation sires resulting from *inter se* mating; **genetic group 3**: sires belonging to subsequent generations and **genetic group 4**: 4/8 Red Danish:1/8 Red Poll:3/8 Zebu sires.

The heritabilities were estimated from paternal half-sib correlation using the following formula:

$$h^2 = 4\sigma^2_{b:a}/(\sigma^2_{b:a} + \sigma^2_e)$$

where:

$\sigma^2_{b:a}$ = variance component for effect of sire: genetic group;
σ^2_e = variance component for residual (error) effects.

The genetic correlations were estimated following the method described by Calo *et al.* (1973b), which is based on the correlation between breeding values (or predicted differences) estimated for the traits to be correlated. This method also provides the expected response for performance of next generation progeny of evaluated sires, either for the principal trait or for the secondary trait.

According to this methodology, the genetic correlation (r_g) between different characters measured in half-sibs of the two sexes can be estimated by the following expression:

$$r_g = r_{(PD1,PD2)}/\sqrt{(b_1 b_2)}$$

where:

$r_{(PD1,PD2)}$ = correlation between the predicted differences obtained for traits 1 and 2;
$b_i = P_i h_i^2/[4 + (P_i - 1)\, h_i^2]$ (weighing factors for traits 1 and 2);
P = number of progeny.

The mixed model method, described by Henderson *et al.* (1959) and Henderson (1974), was used to obtain unbiased linear predictors (Best Linear Unbiased Predictor - BLUP) in the sire evaluation.

The accuracy of estimates of genetic correlations was obtained by the approximation given by Robertson (1959):

$$SE(r_g) = \frac{1 - r_g^2}{\sqrt{2}} \cdot \frac{\sqrt{SE(h_1^2)\, SE(h_2^2)}}{\sqrt{h_1^2 h_2^2}}$$

where:

$SE(h_1^2)$ = standard error of h^2 estimated for character **1**; and
$SE(h_2^2)$ = standard error of h^2 estimated for character **2**.

RESULTS AND DISCUSSION

Overall means and respective coefficients of variation for 1,567 milk records were 1.999 kg and 63% for MY305 and 234 days and 50% for lactation length. For 1,774 weight records of steers, the overall means and respective coefficients of variation were: 28.72 months and 17%, for age at allocation to feedlots; 364.8 kg and 16% for WAF; and 0.421 kg and 16% for LWA.

Although these measurements came from a commercial herd and were not obtained from planned designed experiments, this information provided an opportunity to study genetic associations of milk and meat production with a reasonable amount of data.

Table I shows the analysis of variance for MY305, WAF and LWA.

The heritabilities estimated for MY305, WAF and LWA were: 0.31 ± 0.07, 0.29 ± 0.07, and 0.27 ± 0.07.

Predicted differences

Predicted differences for milk yield (MY305) ranged from -521 to 612 kg. The average repeatability was 0.58, with an average number of progeny per sire of 33. Predicted differences for weight at allocation to feedlots (WAF) and live-weight-for-age (LWA) ranged from -14 to 22 kg, and from -0.014 to 0.021, respectively. The average repeatabilities for these traits were 0.60 and 0.59, with an average number of progeny of 42 and 41, respectively.

Genetic correlations

The correlation coefficients between the predicted differences for MY305 and beef traits (WAF and LWA) as well as the estimates of the genetic correlation are summarized in Table II.

Table I - Analysis of variance for 305-day milk yield (MY305), weight at allocation to feedlots (WAF) and live-weight-for-age (LWA).

Sources of variation	Degrees of freedom	Mean square	F	P
MY305				
Genetic group	3	4,530,364	1.50	0.2226
Sire: genetic group	66	3,028,806	2.61	0.0001
Year-season	14	2,899,417	2.50	0.0001
Remainder	1,483	1,159,801		
WAF				
Genetic group	3	2,828	0.61	0.6147
Sire: genetic group	48	4,672	3.28	0.0001
Feedlot year	4	25,267	17.75	0.0001
Regression (age)				
linear effect	1	1,739,441	1,221.84	0.0001
quadratic effect	1	2,899,417	2.50	0.0001
Remainder	1,483	1,159,801		
LWA				
Genetic group	3	0.0057	0.94	0.4300
Sire: genetic group	47	0.0060	2.96	0.0001
Birth year	5	0.2421	118.53	0.0001
Birth season	3	0.0673	32.89	0.0001
Feedlot year	4	0.2421	120.02	0.0001
Remainder	1,681	0.0020		

P: Probability associated with F test.

Table II - Correlation coefficients (r_{MB}) between predicted differences for MY305 and beef traits (WAF and LWA) and estimates of genetic correlations (r_g) between them.

Traits	r_{MB}	r_g
MY305 and WAF	-0.14	-0.24 ± 0.15
MY305 and LWA	-0.20	-0.35 ± 0.14

Abbreviations as in Table I.

Genetic correlations between beef traits measured in males, and milk yield of related females, whether positive or negative, are usually small. A survey of the literature shows, in general, variation in estimates of the genetic correlation between milk and beef production traits, other than carcass traits; e.g., values close to zero (Mason, 1964; Soller *et al*., 1966; Mason *et al*., 1972 and Calo *et al*., 1973b), positive values ranging from 0.16 to 0.38, and low, and negative values, ranging from -0.10 to -0.68 (Langlet, 1965; Mason *et al*., 1972 and Calo *et al*., 1973a). Most of the negative estimates were obtained for beef traits measured at more advanced ages.

The low estimates reported for the genetic correlation between milk and meat production in the literature suggest that selection for milk production does not affect the weight of animals, that is, there is no antagonism between these characters. Such a conclusion implies that the emphasis of selection could be shifted to either milk or meat production without adverse effects on the other trait. The absence of any serious antagonism between milk and beef production also suggests the effectiveness of simultaneous selection for both traits, depending on the market and economic conditions.

A similar tendency was also observed in the present study. To evaluate effects of selection for milk production on weight performance of Pitangueiras cattle, correlated responses for WAF and LWA were calculated. The top sires ranked based on predicted differences for MY305 and their respective predicted differences for WAF and LWA were used. The fractions of selected sires were 10%, 15% and 20%. Table III shows the predicted differences for MY305, WAF and LWA, of the top 20% sires, ranked according to MY305.

Table III - Predicted differences for MY305, WAF and LWA, of the top 20% sires classified on the basis of MY305.

Sire number	Genetic group	MY305 (kg)	WAF (kg)	LWA (kg)
23	3	612	8.31	-0.0145
30	2	495	8.29	0.0072
25	3	382	-2.72	-0.0092
18	4	326	4.71	0.0084
38	3	253	-6.26	0.0010
16	4	246	21.47	0.0209
06	2	212	-3.00	-0.0019
02	1	209	-0.84	0.0013

See Table I for abbreviations.

The average predicted differences, or expected average progeny performance for next generation for each trait and each selection fraction are in Table IV.

Selection for milk production did not result in a negative correlated response for WAF and LWA, when considering the three fractions of selection. Taking into account the error associated with each prediction, selection of the top 20% will be discussed. Selection of the best eight sires for MY305 is expected to result in weights of their male progeny at allocation to feedlots to be 1.667 kg superior to the average weights of contemporaries. This correlated response is similar to

Table IV - Empirical responses to selection for milk production (MY305) and empirical correlated responses for WAF and LWA with selected fractions of 10%, 15% and 20%.

Fraction of selected sires	MY305 (kg)	WAF (kg)	LWA (kg)
10%	454	0.492	-0.0020
15%	437	2.863	0.0023
20%	394	1.667	0.0016

See Table I for abbreviations.

the expected correlated response calculated for live-weight-for-age (1.445 kg) obtained by multiplying average daily gain of 0.00165 kg by the average age at allocation to feedlots (28.723 months).

Although the magnitude of these expected responses is small, they are positive, which is not expected because of negative correlations.

If sires had been ranked by WAF or LWA, the empirical correlated responses for MY305 would be -119 kg and -96 kg, respectively (Table V). Thus, the antagonism resulting from the negative correlations between MY305 and weight performance traits is expressed among animals with low predicted differences for MY305, that is, sires of low predicted differences for MY305 showed high predicted differences for WAF and LWA (see Figures 1 and 2). These results suggest that milk yield selection as it has been practiced for about 40 years has not caused detrimental effects on the weight performance of males. However, care must be taken with this conclusion because of the small sample size and probable large standard errors of empirical responses.

We must be careful when making recommendations from a relatively small sample or based on a few selected animals because the next generation may be completely different. For the present situation, three alternatives in terms of selection objectives could be discussed, depending on the current economic policy or market conditions:

a) Selection for milk yield

If the major interest is milk production, with sale of young males not used for breeding purposes and slaughter of culled females, the selection as it has been conducted for about 40 years would not negatively affect the weight of animals. Another possibility for the farmer who keeps the males until more advanced ages is to raise them for meat production, or else, to sell them to farmers specializing in raising cattle for slaughter.

b) Selection for meat production

If the breeding goal changes to meat production, with milk production as a secondary goal, selection should emphasize sires with the greatest predicted differences for weight traits. Figure 1 shows the predicted differences of sires ranked by WAF and LWA, and their respective predicted differences for MY305. Just one sire had high predicted differences for both weight performance and milk yield (sire number 16, see Table V). Reduction in milk production occasioned by the negative expected response calculated for MY305 does not constitute a problem in the present situation.

Table V - A. Predicted differences for WAF and MY305, for the top 20% of Pitangueiras sires ranked according to WAF. B. Predicted differences for LWA and MY305, for the top 20% of Pitangueiras sires ranked according to LWA.

A				B			
Sire number	Genetic group	WAF (kg)	MY305 (kg)	Sire number	Genetic group	LWA (kg)	MY305 (kg)
21	4	22.17	-261	16	4	0.0209	246
16	4	21.47	246	21	4	0.0203	-261
32	3	16.94	-12	20	4	0.0148	-58
20	4	15.57	-58	07	3	0.0130	-19
07	3	11.95	-19	32	3	0.0129	-12
28	3	11.10	-325	42	3	0.0126	-246
42	3	10.10	-246	22	3	0.0116	-97
01	1	8.31	-267	28	3	0.0109	-325

See Table I for abbreviations.

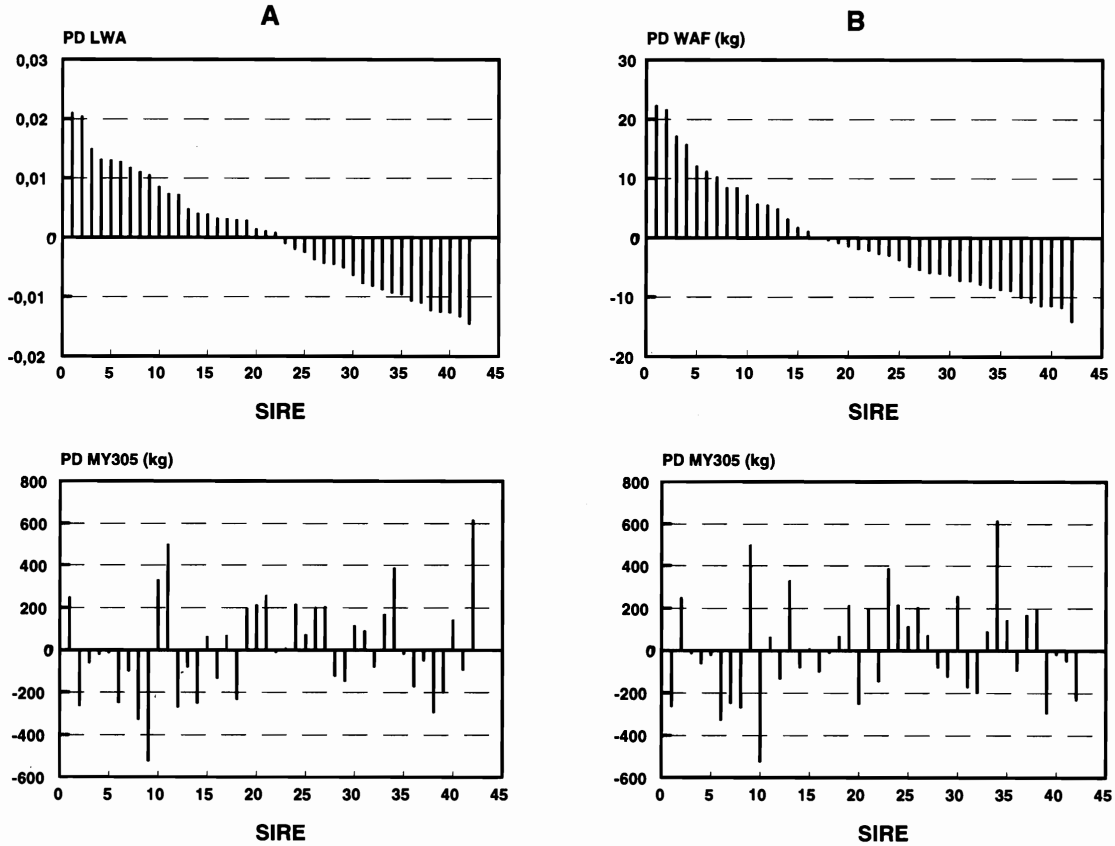

Figure 1 - Predicted differences of Pitangueiras sires, ranked on weight at allocation to feedlots (WAF[a]) and live-weight-for-age (LWA[b]) and their respective predicted differences for 305-day milk yield (MY305).

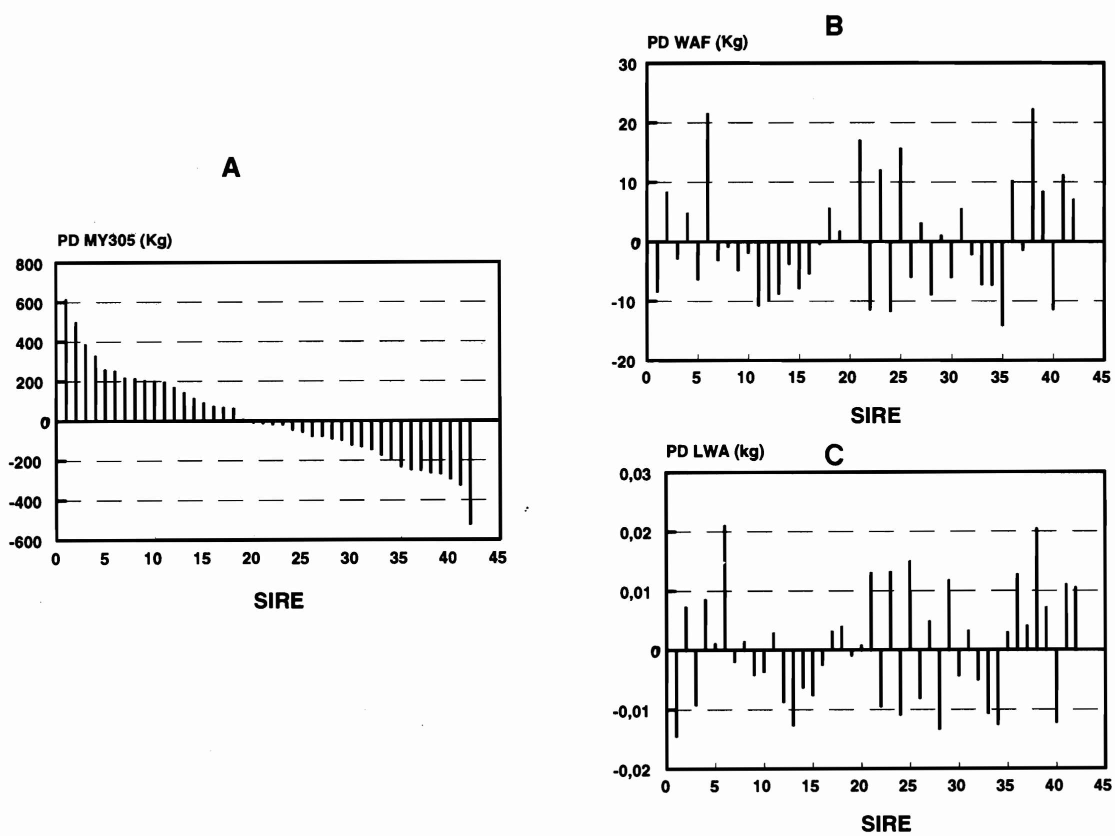

Figure 2 - Predicted differences of Pitangueiras sires ranked on 305-day milk yield (MY305[a]) and their respective predicted differences for weight at allocation to feedlots (WAF[b]) and live-weight-for-age (LWA[b]).

c) Simultaneous selection for milk and meat production

Finally, suppose the breeding goal is to select animals with an adequate genetic balance of milk and meat production traits. Thus, for the present situation the selected sires should have positive predicted differences for MY305, and for weight traits. When two or more characters constitute the breeding goal of a breeding program, the correct procedure is to establish selection indexes for sire evaluation (Hazel, 1943), including the economic value of each trait. The selection index would provide the aggregate or economic genetic value of each sire. The success of selection based on economic values depends on three main factors: The breeding values must be estimated with accuracy; the net economic values must be calculated adequately, and the genetic correlation estimates must be close to the true nature of genetic correlation, otherwise it may lead to incorrect selection decisions (Van Vleck *et al.*, 1987).

Due to uncertain economic policies, fluctuations of prices of fertilizers, concentrates, milk and meat, and the high inflation often observed in Brazil, it is quite difficult to obtain reliable estimates of economic values for breeding purposes. Thus, an alternative suggested for this situation is selection of sires with high predicted differences for both traits. Figure 2 shows the predicted differences of sires ranked by MY305 and their respective differences for WAF and LWA. The best sire for MY305 showed negative predicted differences for WAF and LWA. The same situation was true for the third best sire, and the fifth sire showed negative predicted difference for WAF. On the other hand, the second, fourth and sixth ranked sires had positive predicted differences for all traits, desirable for joint selection for meat and milk.

CONCLUSIONS

The estimated genetic correlations between MY305 and weight performance traits (WAF and LWA) suggest that there is an antagonism between milk yield and weight traits. However, the empirical correlated responses calculated for WAF and LWA indicate that selection for milk production does not decrease the weight performance of males. A hypothesis is that the possible antagonism resulting from negative correlations would be expressed among sires with low predicted differences for milk yield, that is, these sires may show high predicted differences for beef traits. For animals studied in the Pitangueiras herd, selection for milk production did not cause detrimental effects on weight gain.

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RESUMO

O objetivo do presente trabalho foi obter as diferenças preditas dos reprodutores para produção de leite e de carne, visando estimar a correlação genética entre a produção de leite (com base na primeira lactação de suas filhas) e as seguintes características: peso no início do confinamento e ganho diário até o início do confinamento (medidos nos seus filhos, confinados ao redor dos 28 meses) e calcular a resposta correlacionada esperada para estes caracteres, em um rebanho da raça Pitangueiras, criado no Estado de São Paulo. Foram analisados dados referentes a 1.567 lactações de filhas de 70 touros e 1.776 registros de filhos de 52 touros, contendo os pesos no início do confinamento, ganho diário em confinamento, peso ao abate e ganho diário até o início do confinamento. As médias observadas com seus respectivos coeficientes de variação (CV) foram as seguintes: 1930 kg (CV = 56%), para a produção de leite aos 305 dias (PL305); 234 dias (CV = 50%), para a duração da lactação (DL); 365 kg (CV = 16%), para o peso no início do confinamento (PESOIC); 28 meses (CV = 17%), para a idade na entrada do confinamento (IDENTRADA); e 0,421 kg (CV = 13%) para o ganho diário até o início do confinamento (GANHOVIDA). As diferenças preditas para PL305 variaram de -521 kg a 612 kg. As diferenças preditas obtidas para PESOIC e GANHOVIDA variaram de -14 kg a 22 kg; e -0,014 kg a 0,021 kg, respectivamente. As estimativas de correlação genética entre PL305 e PESOIC e PL305 e GANHOVIDA foram respectivamente -0,24 ± 0,15 e -0,35 ± 0,14. As respostas correlacionadas esperadas para as características PESOIC e GANHOVIDA foram, respectivamente, 1,667 kg e 0,0016. Estes resultados indicam que a seleção para produção de leite não deve causar efeitos detrimentais no peso dos animais pertencentes ao rebanho estudado.

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